APPLICATION CASE OF TEST CONSTRUCTION OF RESTORATION ON THE DISUSED EXPRESSWAY

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ABSTRACT

In this study, the survey of disused expressway nationwide was conducted during the period, Jan through Dec 2008 and the trial application of rehabilitation method was carried out in an attempt to develop the rehabilitation design and construction of disused expressway. As a result, the outcome is as follows.

To form the subbase in preparation for restoring the disused expressway, asphalt concrete surface (35cm thick) should be removed before filling the soil layer for planting.

Among the planting methods to rehabilitate the disused expressway, planting with large trees would be more efficient to enhance the early covering effect.

A thin layer hydro-seeding method (with a 1cm subbase layer), among the seeding methods, is expected to provide the effective planting effect. And given the harmony with the surrounding plants, using the natural resources (top soil) would be desirable from ecological standpoint.

To evaluate the rehabilitation method, a medium & long-term monitoring of plants is a must, and application effect of individual method needs to be quantified from the
three aspects such as the ground stability, ecologic features and sustainability and constructability for evaluation.

This study was intended to experimentally apply the diverse methods for rehabilitating the disused expressway, which further require constant monitoring of the process of ecologic rehabilitation, and the methods for recycling the waste asphalt concrete and how to use the restored land need to be considered as well.

1. INTRODUCTION

Road is physical structure that blocks the connection in eco-system, and the once disused road should be restored environmentally because of the limiting factor in eco-system network. In addition, restoration to original state is not suitable for gardening, and the restoring to the natural state always faces the significant difficulty.

Law according to natural environment restoration after road construction is quite limited to certain area, and the establishment and execution basis for the comprehensive restoration plan is weak. Especially, basis for the restoring disused road is not clear, and the usage status should be studied throughout the nation. After the evaluation on the current status, the comprehensive and general approach in restoration project according to priority can be implemented.

Therefore, in this study the feasibility on the road restoration and its evaluation will be given for the disused expressway to utilize as fundamental information to design and future planning.

2. MATERIAL AND METHOD

(1) Test construction

a. Test construction design for restoration work

With consideration on the efficacy and management status on test construction, 1,300 ㎡ of waste ascon is removed, and test sites are installed at 1,170 ㎡ of area. Test construction areas are arranged in rectangular shape and same size, and the planting and seeding method is differentiated.

Table 1. Planning by test construction method

Section	Method	Symbol	Area

Plants	Landscape plant	- Special Pot seeding plant for green works	A-1	225 ㎡
	Pot seeding plant	- Landscape plant for green works	A-2	225 ㎡
Seeding Method	Seed sowing	- Organic basis seeding - Fiber basis seeding	B-1-1 B-1-2	225 ㎡
	Application of local source	- Top soil seeding - Top soil + wood grinding chip	B-2-1 B-2-2	225 ㎡
Control	Seedling	- Pot seeding plant	C-1-1 C-1-2	170 ㎡
	Control	- Untreated	C-2	100 ㎡
Total				1,170 ㎡

(2) Construction material

a. Used seed

During the mixing of seed, the diversity in vegetable system is aimed. 5 types of woody plants 9 types of herbs are mixed, and the weight ratio between woody plants and herbs is 30:70. Expected development is 5.6:94.4.

Mixed quantity for seed is 30 g/㎡, and expected development is 7,525 /㎡. In this time, correction factor K for environment and V for plant is applied to the calculation.

Table 2. Condition for seed mixing

Vegetable name			Expected development	Seeding	Ratio		Germination rate	Purity	Number of leaves	Correction factor(K)	Correction factor (V)
			no./m^2	(g/m^2)	Expected development	Weight	(%)	(%)	leaf/g	environment	plant
Woody plant	Forest tree	Silk tree (*Albizzia julibrissin* Durazzini)	30	3.4	5.6	30.0	40	97	35	0.81	0.8
		Alnus (*Alnus Hirsute* Fischer Var *Sibirica*)	70	0.9			30	60	700	0.81	0.8
		Maple tree (*Acer palmatum* Thunberg)	25	0.5			80	90	100	0.81	0.8
	Shrub	Bush clover (*Lespedeza Cyrtobotrya* Miquel)	200	2.8			60	99	150	0.81	1.0
		False indigo (*indigo ferapseudo-tinctoria* Matsumura)	100	1.4			80	95	120	0.81	1.0
	Sub total		425	9.0							
Herbs	Initial covering	Chinese Lespedeza (*Lespedeza Chiisanensis* T.Lee)	1,500	6.4	94.4	70.0	70	98	700	0.81	0.6
		Pampas (*Miscanthus sinensis* Anderson)	200	0.7			30	80	2,300	0.81	0.6
		Plantain (Plantago Asiatica Linné)	100	0.4			50	50	2,000	0.81	0.6
		Wormwood (*Artemisia Princes* pampanini)	50	0.1			50	80	3,000	0.81	0.6
	scenery	China pink (*Dianthus chinensis* Linné)	900	1.1			80	90	2,000	0.81	0.7
		Dandelion (*Taraxacum mongolicum* Handel-Mazetti)	650	3.2			60	60	1,000	0.81	0.7
		Bird's boot trefoil (*Lotus corniculatus* Linné var. *japonicas Regal*)	1,000	6.6			80	95	350	0.81	0.7
		Wild chrysanthem (*Chrysanthe mum* boreale(Mak.) Makino)	1,500	0.4			70	99	9,000	0.81	0.7
		Aster (*Kalimeris yomena* Kitamura)	1,200	2.1			60	98	1,700	0.81	0.7
	Sub total		7,100	21.0							
Total			7,525	30.0	100	100					

Table 3. Seed for unit bed and seedling

Section	Oak tree (*Quercus* Linné)	Amur tree (*Acer ginnala* Maximowicz)	Pine tree (*Pinus densiflora* Siebold & Zuccarini)	Maple tree (*Acer palmatum* Thunberg)	Sumac(*Rhus javanica* Linné)	Note
Unit bed	○	○				
seedling	○		○	○	○	
Pot seeding	○		○	○	○	
Section	Local collection	Local collection	Purchase	Purchase	Purchase	

b. Applicable tree

The number of seedling was 175 as Pine tree(*Pinus densiflora* Siebold & Zuccarini) (5 types), and 461 of Pine tree(*Pinus densiflora* Siebold & Zuccarini) in 7 types were applied.

Table 4. Trees in the test

Trees	Seedling			Landscape tree			Note
	Application	Size	Quantity	Application	Size	Quantity	
Pine tree (*Pinus densiflora* Siebold & Zuccarini)	●	5 chi pot	30	●	H2.5XR10	6	
Sorbaria (*Pinus densiflora* Siebold & Al.Braun)	●	5 chi pot	40				
Oak tree (*Quercus* Linné)	●	5 chi pot	30				
Purple beauty-berry (*Callicarpa dichotoma* Raeuschel)	●	5 chi pot	40				
Bridal wreath (*Spiraea salicifolia* Linné)	●	5 chi pot	35				
White birch (*Betula platyphlla* sukatschev var. *japonica*(Miq.)Hara)				●	H2.5XB4	15	
Maple tree *(Acer palmatum* Thunberg)				●	H2.5XR5	6	
Cherry tree (*Prunus serrulata* Lindley var.*spontanea* (Maxim.)Wilson)				●	H2.5XB4	5	
Mongolian oak (*Quercus mccormickii* Carruthers)				●	H2.5XR5	5	
Royal azalea (*Rhododendron schlippenbachii* Maximowicz var. *schlippenbachii*)				●	H0.3XW0.3	180	
Azalea (*Rhododendron mucronulatum* Turezaninov var.*mucronulatum*)				●	H0.4XW0.3	243	
Total			175			461	

c. Vegetation environment

Environment is divided by organic and fiber layer, and greening material is classified by imported from outside and local utilization. Local source is used from the top soil in forest. In addition, wood waste from local is applied.

d. Subsidiary material

O Natural fiber net: Net made of cotton string in 0.02 ~ 0.05 mm, and unit size of net is 35 mm x 45 mm.

O Unit bed: Unit bed is made of unwoven cloth. Unit is 30 cm x 30 cm. The region with top soil covering on the center is designed to be 20 x 20 cm. When the top soil is covered on unit bed, thickness will be about 5 cm to provide vegetation environment for germination.

3. RESULTS AND DISCUSSION

(1) Status of test construction site

a. Location overview

For the target of this study, disused expressway at 192.4 km in Youngdong expressway is located at Pyeonchang-gun Gangwon-do. It is near to Taebaek mountain range and Charyeong mountain range including Odaesan National Park. It is a former interchange at Soksa, and Youngdong expressway and National road No. 6 is crossing.

Type of disused road is connection, and 1,300 ㎡ of target site, which is connected to disused road (2 km in length), is selected for study.

Fig. 1 Location of Soksa interchange (192.4 km in Youngdong expressway)

Fig. 2 Selection of test construction site

b. Vegetation environment

At the connection part to the existing forest, natural forest is remained, and the representative mixed forest in middle land of Korea is exhibited.

(2) Test construction

a. Foundation

Ascon is applied on test site with 35 cm of thickness in average. The amount of waste from ascon removal is 1,000 tons. The removal is entrusted to the special construction company. After removal of ascon, saprolite is applied up to 35 cm. It is adjusted to level with the existing road.

b. Test construction

① Vegetation method

ⓐ Plant 1

Total 175 of trees in 5 types, Pine tree(*Pinus densiflora* Siebold & Zuccarini), Sorbaria (*Sorbariasorbifola*(L.) Al.Braun), Oak tree(*Quercus acutissima* Carruthers), Purple beauty-berry(*Callicarpa dichotoma* Raeuschel), and Bridal wreath (*Spiraea salicifolia* Linné) were applied. Size of seedling is set to 5 chi pot, and Pine tree (*Pinus densiflora* Siebold & Zuccarini) and Oak tree (*Quercus acutissima* Carruthers) was planted in 34%.

Fig. 3 Test construction view for vegetation

ⓑ Plant 2

Applied woody plants were White birch(*Betula platyphlla* sukatschev var. *japonica*(Miq.)Hara), Pine tree(*Pinus densiflora* Siebold & Zuccarini), Maple tree(*Acer palmatum* Thunberg), cherry tree(*Prunus serrulata* Lindley var.*spontanea* (Maxim.)Wilson), Mongolian oak(*Quercus mccormickii* Carruthers), royal azalea(*Rhododendron schlippenbachii* Maximowicz var. *schlippenbachii*), and Azalea(*Rhododendron mucronulatum* Turezaninov var.*mucronulatum*). Size of Pine tree(*Pinus densiflora* Siebold & Zuccarini) as target species was H2.5 X R10. Size of Mongolian oak(*Quercus mccormickii* Carruthers) is H2.5 X R5.

Fig. 4 Test construction view for landscape tree

② Seeding method

ⓐ seeding 1-1

This site is aimed to forest restoration by seed sowing, and vegetation is based on organic material for development.

Thickness is set to 1 cm, and used seed is based on 30 g/㎡ for 14 types. Along with this, fiber net is installed, and subsidiary material is mixed such as growth promoter.

Fig 5. Mixing view for seeding

ⓑ Seeding 1-2

This site is aimed to forest restoration by seed sowing, and vegetation is based on fiber layer for development.

Thickness is set to 1 cm same as 1-1, and used seeds were total 14 types in 30 g/㎡.

Subsidiary material such as fiber net is applied.

Site 1-1 and 1-2 is utilized the same seeds, and compares the development difference by formulation method.

ⓒ Seeding 2-1

Mixing ratio of top soil in vegetation was 10% as total. Depth of vegetation is set to 1 cm, and the basis of seeding is 30 g/㎡ for 14 types.

For the development of target species, seeds of Oak tree(*Quercus* Linné*)* and Amur maple(*Acer ginnala* Maximowicz) is collected at the site, and installed at seedbed. Unit bed is 30 x 30 cm, and fixing pin is installed at the bottom. Distance with 2 meters for 0.36 ea/㎡ is kept. In addition, fiber net as subsidiary material is installed.

Fig 6. Test contruction view for sowing

ⓓ Seeding 2-2

Mixing ratio of top soil is 10% from total material, and wood crushed chip is selected with 25 mm screen after separate process. Chip is also mixed as top soil, 10%.

Thickness of vegetation is set to 1 cm, and used seeds were applied according to 30 g/㎡ for 14 types. For the development of target species, seeds of Oak tree(*Quercus* Linné) and Amur maple(*Acer ginnala* Maximowicz) is collected and installed at unit bed (30 x 30 cm). Fixing pin is used for adhesion on ground. Unit bed is spread as 36 /㎡ in 2-meter distance. Fiber net is installed.

Seeding 2-1 and 2-2 utilizes the mixing of local source, and comparison test is executed to determine the detailed process in restoration.

ⓔ Control 1

Test sites (C-1-1, C-1-2) were implemented to confirm the genetic resource for disused road restoration. To obtain the applicable local seedling, seed is collected or purchased as similar type. 4 types of seeds were for pine(*Pinus densiflora* Siebold & Zuccarini), oak(*Quercus* Linné), maple(*Acer palmatum* Thunberg), and Sumac(*Rhus javanica* Linné). Seedbed for pot soil is utilized 50-hole pot, and top soil is covered. After that, seed is sown by one at a time. For local vegetation, seeds were sown with 20 cm of groove and 1 meter of width.

On seeded, rice straw is mulched, and sun blocking is also mulched to improve moisture containment and seed loss.

Along with this, control for untreated group is not processed after molding of saprolite. It is left for the natural restoration.

③ Monitoring

ⓐ Soil and organic content analysis

During the restoration process as ecological forest after the removal of waste ascon, the foundation layer should be formulated to develop of woody herbs.

Therefore soil properties after removal of ascon will be the important factor to vegetation restoration.

Table 5. Organic content and soil property

Name	Organic(%)	Sand(%)	Silt(%)	Clay(%)	Property
Top soil	0.98	85.28	6.80	7.92	Loamy sand
Pebble 1	1.27	89.04	1.88	9.08	Loamy sand

Pebble 2	1.20	88.04	3.40	8.56	Loamy sand
Saprolite 1	1.05	80.00	9.04	10.96	Sandy loam
Saprolite 2	0.78	72.52	16.40	11.08	Sandy loam

Raw ground after the removal of ascon will be in good nutrition status, and rooting of vegetable will be considered as good. Due to the high count of sand, drainage performance will be excellent.
On the other hand, organic content in soil is 0.78 ~ 1.27%, and it is very low compared to forest soil.

Fig 7. Investigation view for the foundation layer

ⓑ Hazardous heavy metal analysis

Ministry of Environment classifies the purpose of soil according to 11 items in soil contaminants. For each type, concerning level of soil contamination and countermeasure level to soil contamination will be designated.

Table 6. Content of heavy metal

Specimen		Cd (mg/kg)	Cu (mg/kg)	Pb (mg/kg)	As (mg/kg)	Hg (mg/kg)	Cr6+ (mg/kg)	Zn (mg/kg)	Ni (mg/kg)
Concerning level	(a) location	1.5	50	100	6	4	4	300	40
	(b) location	12	200	400	20	16	12	800	160
Evaluation site	Top soil	0.02	0.50	1.11	0.30	ND	0.50	49.08	7.50
	Saprolite 1	0.02	0.30	1.17	0.52	ND	0.30	71.19	11.83
	Saprolite 2	0.02	0.40	1.33	0.50	ND	0.54	65.64	10.91
	Pebble 1	0.02	0.92	0.93	0.27	ND	0.21	61.40	13.60
	Pebble 2	0.02	0.67	0.99	0.28	ND	0.20	51.72	10.73

According to soil contamination criteria from ME, it is considered as “not contaminated.”

ⓒ Evaluation by germination count

After 1 week from construction, germination is started. After 1 month from construction, 11~32 /0.04 ㎡ is achieved, but the classification by individual vegetation is difficult.

Therefore, it takes some time to achieve the covering with 274 ~ 800 /㎡ of sown vegetation.

Table 7. Germination count by test location

Sample No.	Number of germination			
	B-1-1	B-1-2	B-2-1	B-2-2
1	35	28	73	54
2	24	5	42	7
3	8	14	11	12

4	10	7	19	2
5	3	10	16	8
6	7	33	78	62
7	10	24	41	41
8	4	8	24	15
9	4	3	12	3
10	9	4	3	9
Average	11.40	13.60	31.90	21.30

4. CONCLUSION

In this study, restoration work has been conducted from January 2008 to December 2008 for the establishment of restoration plan and execution guideline on disused expressway.

For the foundation development on the restoration of disused expressway, ascon layer is removed (35 cm thick), and soil layer in similar thickness is molded to prepare the background for vegetation.
Among the planting methods of tree and herbs for the restoration of disused expressway, landscape tree is the most efficient one.
Among the seeding method, thin layer of vegetation (1 cm) can feature efficient greening. If hazardous waste is not included, certain level of organic will develop the promising results. For the harmonization to surrounding vegetation, local source utilization is the most reasonable choice. For the resource recycling aspect, the wood waste such as crushed wood chip can be mixed.
In this study, the various methods of constructions were applied to restore disused road in asphalt pavement. Further and continued monitoring on eco-system restoration is needed, and the similar test setup is needed to be applied on concrete pavement. In addition, the recycling method on waste ascon and utilization of restored green is needed to be considered.

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